United States
Department of
Agriculture

Forest Service

November 1986

Forestry Research West

A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture.

Forestry Research West

In This Issue

Cover

Scientists at the Pacific Southwest Station are perfecting genetic engineering of trees — a technology that should help develop trees that grow quickly, and can withstand environmental factors such as insects and diseases, cold, and drought. In the past, genes were transferred by cross pollination (shown here) — a time-consuming and highly unselective process. The latest research results makes possible the precise transfer of single genes. Read more about these important studies on page 1.

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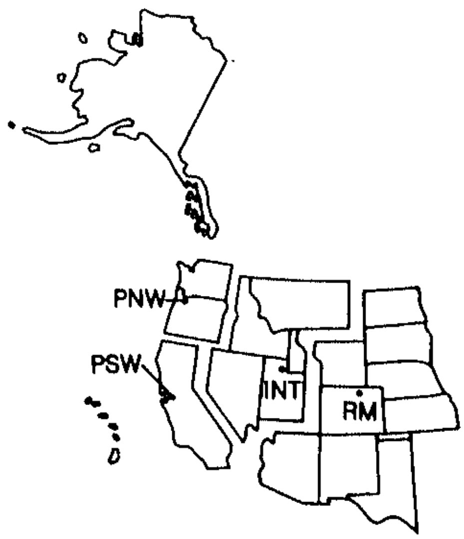
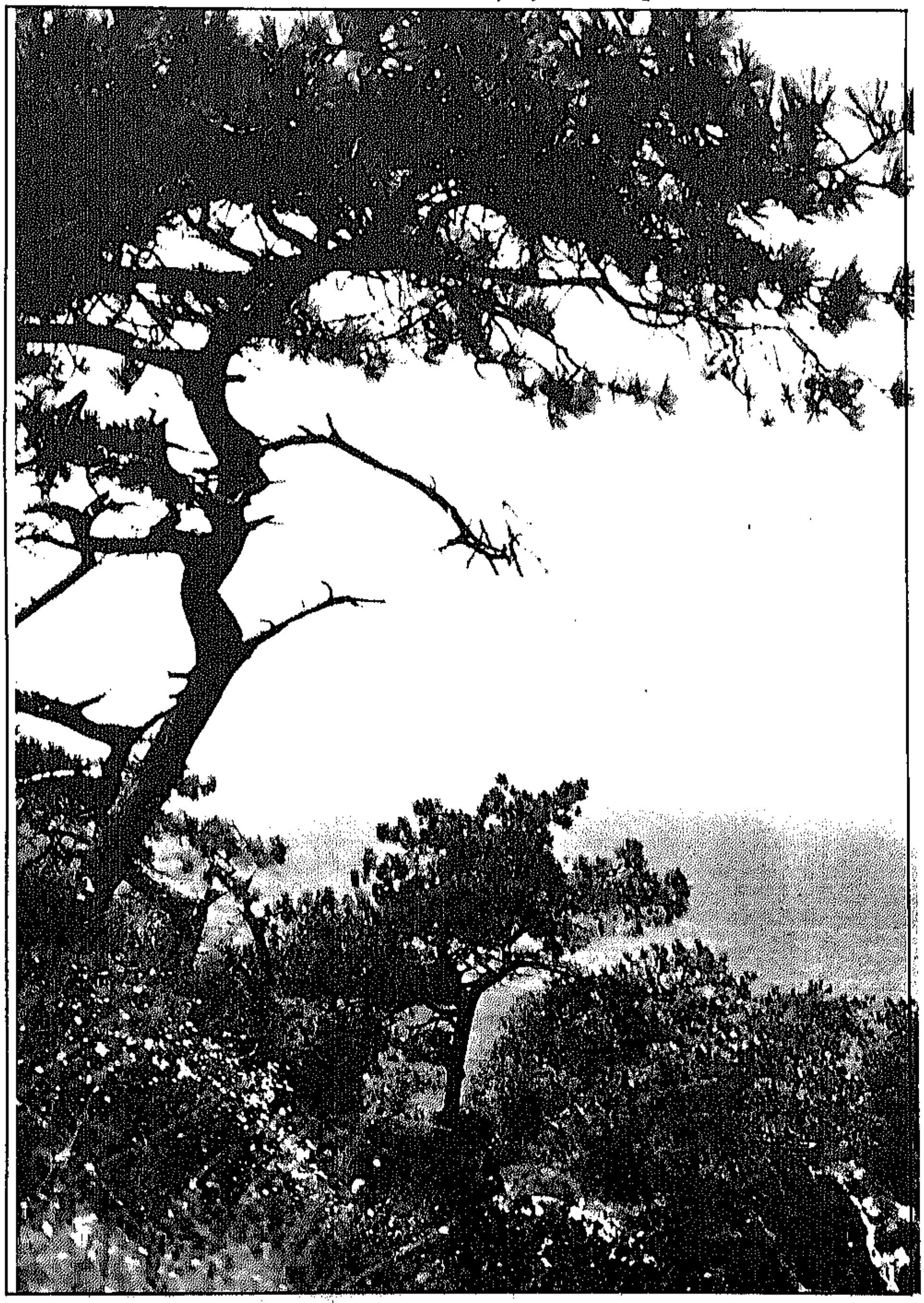


Genetic engineering comes to forestry

by Richard B. Pearce

To develop trees that are resistant to disease, that grow quickly even in impoverished soils, or that are able to withstand toxic chemicals or frost has been the quest of forest biologists for many years. For most of that time, breeders have employed the age-old methods of cross-breeding to improve forest stocks. Unfortunately, relying on traditional methods to introduce the desirable trait of one species into another is tedious, time consuming, and more often than not, unsuccessful. Even when a likely hybrid is developed, it may take years of testing in the field to prove its staying power.



But now, thanks to a technology invented by American scientists in the early 1970s and currently being perfected by consortia of industry, entrepeneurs and government, it soon may be possible to endow important tree species with the outstanding chacteristics of others, and do so in a fraction of the time it would take using conventional methods. What's more, by speeding up the process of mutation, or borrowing favorable characteristics from food crops or even animals, geneticists should be able to bring to trees traits that are currently denied them in Nature.

Gene splicing: new tool for foresters

If all that sounds futuristic, it is. Until very recently, the technology of recombinant DNA — popularly known as gene splicing — has not been vigorously applied to the needs of foresters. But for the geneticists at the Institute of Forest Genetics, part of the Pacific Southwest Station headquartered in Berkeley, CA, the prospect of being able to custom design a tree is just around the corner.

Information important to the management and conservation of rare species, such as this Torrey pine, resulted from the early use of molecular technologies. By characterizing its enzymes, forest scientists found that Torrey pine was genetically uniform and, therefore, much more vulnerable to environmental changes than variable species like ponderosa pine.

"Reaping the benefits of recombinant DNA technology as applied to forestry is coming close to reality, now simply a matter overcoming a few technical barriers," says F. Thomas Ledig, leader for the research unit managing the Institute of Forest Genetics. "Already many genes of potential value to forestry have been isolated and within the next few years we hope to be able to successfully introduce several of these into tree species."

The Institute, located near Placerville, California, is one of only two U.S. Forest Service facilities engaged in genetic research at the molecular level.

Their adventurous five-year plan calls for the isolation and mass production of disease resistant genes from sugar pine, the testing of various schemes designed to insert these and other genes into the DNA of tree cells, and finding ways of getting the freshly transplanted genes expressed in adult trees. It's not easy, transposing commercial methods of gene splicing to forestry. For one thing, most recombinant DNA technologies rely on bacteria or yeast as hosts. These simple organisms will accept almost any gene and obligingly produce the protein for which it codes. Inexpensive human insulin, growth hormone, interferon, and an anticlotting factor for heart patients are some of the products that have already reached the marketplace, thanks to their easy and rapid mass production in bacteria.

Unfortunately, more complicated organisms like plants and animals aren't nearly as accommodating as bacteria or yeast; it's never known with certainty whether a transplanted gene will be expressed efficiently in the adult — if at all. For one thing, most, genes in adult plants and animals are shut off, having served their purpose during growth and development. A transplanted gene, if it ends up in one of these dormant regions may simply be ignored. Ways will have to be found to activate the gene or make sure the transferred gene will activate itself (as some viruses do) when inserted into the host cells.

Closely related tree species should readily accept and express each another's genes, so the real problems facing forest geneticists are of a more technical than theoretical nature.

"It's just a matter of putting the pieces together," says Ronald R. Sederoff, a plant research molecular geneticist who recently joined the Institute's research team.

Crown gall: the key

One of the biggest pieces was recently supplied by Sederoff and his coworker Anne-Marie Stomp, a visiting scientist from North Carolina State University in Raleigh. The two scientists demonstrated for the first time a practical means of introducing foreign genes into pines.

To get alien genes into pine cells, the researchers turned to a natural system that has been used successfully to engineer tobacco and other angiosperms but never before pine.

They take advantage of the fact that *Agrobacterium tumefaciens*, the causative agent of crown gall, inserts a part of its DNA into the host cell's nucleus during the course of infection. This small DNA segment called a plasmid, carries genes that direct the plant cell to manufacture unusual products that may be used for the growth and reproduction of the bacterium.

It is theoretically possible to develop strains of *Agrobacterium tumefaciens* that could introduce into the cells of the crown gall host any one or a combination of desireable genes. That's because once they are isolated, other genes like that for blister rust resistance from the sugar pine, can be combined with the bacterial plasmid and transported into the pine cell by the natural infection process.

Until now, though, no one has been able to get crown gall to infect pine — the trees that will need to receive transplanted genes if a commercially successful gene splicing industry is ever to become a reality in forestry.

Sederoff and coworkers were able to find two strains of *A. tumefaciens* that were both able to induce gall formation eight weeks after inoculation. Galls appeared on 5 percent of the seedlings and 2.6 percent of germinants (infected cotyledons).

To verify that genetic material from the bacteria had in fact been transferred, the scientists measured opine levels in callus tissue. Opines are biochemicals not found in free-living crown gall bacteria or in non-transfected plant cells and, therefore, signify that a transfer of bacterial genes has taken place.

"Their results provide strong evidence for transfer and expression, of bacterial genes in pine, and extend the potential of genetic engineering to the worlds most important genus for fiber production," says Ledig of the achievement.

Sederoff is confident that it will be possible to infect any pine one chooses with crown gall; genetic engineering will not be limited to lobolly. Already the technique has been extended to ponderosa, sugar, and other pines.

But scientists may not have to rely on *Agrobacterium* or their plasmids to carry genes into plant cells; other means of transferring DNA are being developed.

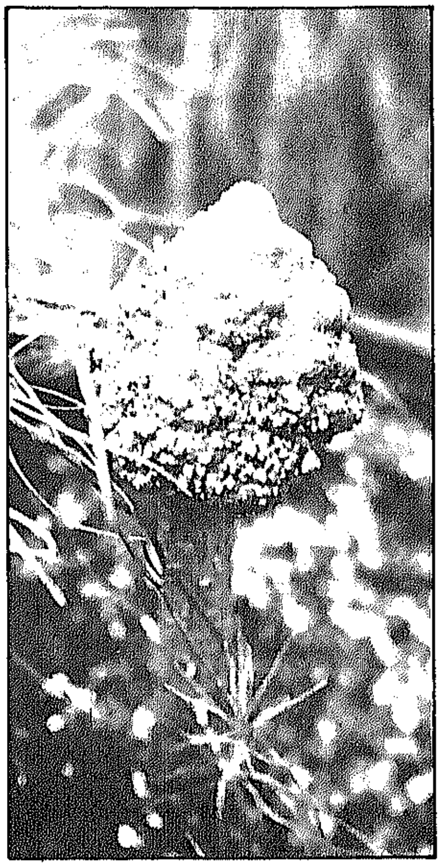
One promising method is microinjection. Used successfully in animal cells, the technique uses fine needles to inject small pieces of DNA into the cell. The DNA fragments are then taken into the nucleus, where they insert into the plant cell's DNA. One difficulty in using the technique for conifers is their thick cell walls, a technical problem that forestry researchers are currently trying to resolve.

Tailored trees

Assuming a successful way of transferring DNA into the cells of important pines is achieved — by whatever method — the question looms: which genes are likely to be inserted first? Ironically, they probably won't come from trees at all for the simple reason that no useful tree gene has yet been isolated. Genes from other sources, however, may prove quite valuable when introduced into trees. The gene for herbicide resistance, for example, has already been isolated from plants and is "on the shelf" waiting to be transplanted.

Another gene of value being considered for transplantation is the insecticidal gene from the bacterium *Bacillus thuringiensis*. The gene produces a toxin against lepidoptera and, once implanted in trees, may effectively ward off such dreaded pests as the gypsy moth, the pine tip moth, the Douglas-fir tussock moth, and the spruce budworm.

Genes can come from any source: fungi, bacteria, plants, or animals. Two likely transplant candidates from pines are the gene from sugar pine (*P. lambertiana* Dougl.) responsible for resistance to white pine blister rust, and a gene for apical dominance in Scots pine (*P. sylvestris* L.). Both are dominant genes but neither has been introduced into another species by traditional crossbreeding methods.



The gall on this loblolly pine seedling was produced when Agrobacterium tumefaciens *inserted genes for growth hormones into the tree's DNA, resulting in over-production of hormones.*

Isolating genes

But isolating genes from pines isn't going to be easy. Genes like that giving resistance to white pine blister rust remain buried in the sugar pine's DNA like the proverbial pin in a haystack. And a large haystack it is! Each pine cell has 174 times the amount of DNA as a fruit fly and nearly 5 times more than a human cell.

How do geneticists find the genes they're looking for? Traditionally, the approach is to work in reverse. By purifying and analyzing the primary structure of the protein for which the target gene codes, it is possible to decipher the gene's DNA sequence (the amino acid code of protein is translated into the nucleic acid code of DNA). Then, a small portion of the gene is synthesized in the laboratory and because it will attach only to those stretches of DNA having the same genetic code, it can be used to probe the entire genome for the closest match. Unfortunately, in forest trees, the protein products of the valuable genes aren't yet known, and until they are, a different approach for isolating genes will have to be used.

One alternative method for homing in on a gene is to locate its closest identifiable neighbor and use it as a marker for the desired gene's whereabouts. The scientists at the Institute of Forest Genetics have already set the stage for such an approach by identifying some 60 such gene markers in pine.

Most are genes that code for common metabolic enzymes that aren't likely to be of developmental importance and so are not candidates for gene transfer themselves. But if any prove to be closely linked to a desirable gene such as that for white pine blister rust, then they can be used to help designate where on a chromosome the important genetic sequence lies.

So far, only weak linkage has been demonstrated between a gene that's a transplant candidate and a marker. Institute Researchers M. Thompson Conkle and B.B. Kinloch have found that the gene conferring resistance to blister rust is relatively close (in conifer terms) to the gene

for 6-phosphogluconate dehydrogenase. Unfortunately, it's not nearly close enough to be of practical value in isolating the blister rust gene. The search continues for markers that are closer still to the important genes needed for successful engineering.

To accelerate the hunt for markers, the Institute's researchers are borrowing yet another method from the gene splicer's bag of tricks. The technique is called restriction mapping. It uses special enzymes to cut DNA into millions of small fragments, each of which can then be examined for the presence of candidate genes and their markers. Restriction fragments can be recognized by how long they are and which of several enzymes was needed to cut it. After probing the fragments for genes and their markers, a restriction map of the various gene locales can eventually be deduced.

Restriction mapping has the advantage over isozyme linkage mapping alone, in that the marker genes don't have to be "switched on," that is, be producing proteins. Some marker genes, such as that which codes for lactate dehydrogenase, are active only during short periods in a plant's lifetime. But using restriction mapping and genetic probes, the DNA fragments from any cell of the plant can be assayed directly at any time.

Still another way of locating a gene is to make it more conspicuous. For instance, if a gene is made defective by inserting another gene into it for which a probe already exists, it would be possible to use that probe to fish out both genes. Though still largely theoretical, Sederoff thinks the approach could be used to help find the blister rust gene and other pine genes.

One last hurdle: growing the trees

But even if valuable genes are isolated and crown gall proves to be a sure-fire way of introducing them into pines, there remains one last and formidable hurdle.

"The inability to regenerate conifers from single cells is currently the biggest obstacle standing in the way of the application of recombinant DNA techniques in forestry," says Ledig. "If the methods of vegetative propagation that have been successful in other plants, such as tobacco, could be applied to trees, it would be possible to generate large numbers of improved plantlets in only a few years."

Intensive research is underway at several research centers to develop ways of growing whole trees from single cells in culture.

"A system for regenerating a tree from a single cell in poplar is fairly well established," notes Sederoff. "But in conifers, the best you can do is to induce needles to produce shoots, then under a different set of conditions, roots." An adult pine tree has yet to be produced starting with a single cell.

Research into plant regeneration has been given a boost recently with the announcement by Japanese workers that they have been able to grow whole rice plants from single cells by at least two separate techniques. Whether similar methods will have equal success in pine, only time and more research will tell.

Discovering a way to coax single cells to grow into plantlings would provide the final link in the attempt to genetically engineer forest trees. It would have many other benefits, too.

The hunt for new genes

Among other things, a successful regeneration system would allow the mass production of genetically identical trees and help in the discovery of new genes. By screening thousands upon thousands of cells in a short period of time, scientists could look for naturally occurring gene mutations or those artificially induced by chemicals or physical stimulants that might, in the end, convey a tremendous survival value to the adult plant.

While still in the single-cell stage, these potential plantlings would be subjected to cold temperature, osmotic shock, pesticides, or mineral-poor solutions. Those that survived would then be grown into adult plants and tested to see whether the resistance lasts. The technique, called somaclonal selection has been used successfully to uncover genes for herbicide resistance in tobacco and should work in trees as well.

Somaclonal techniques have several benefits over traditional methods of trait selection in the past; desirable characteristics had to be tediously selected from large numbers of trees. All the time, not more than one or two traits could be selected. But shopping for traits among cells, rather than whole plants, demands no more space than a lab bench and increases selection pressure many fold over that which occurs naturally. The time required to find (or produce) a new trait is measured in days instead of years.

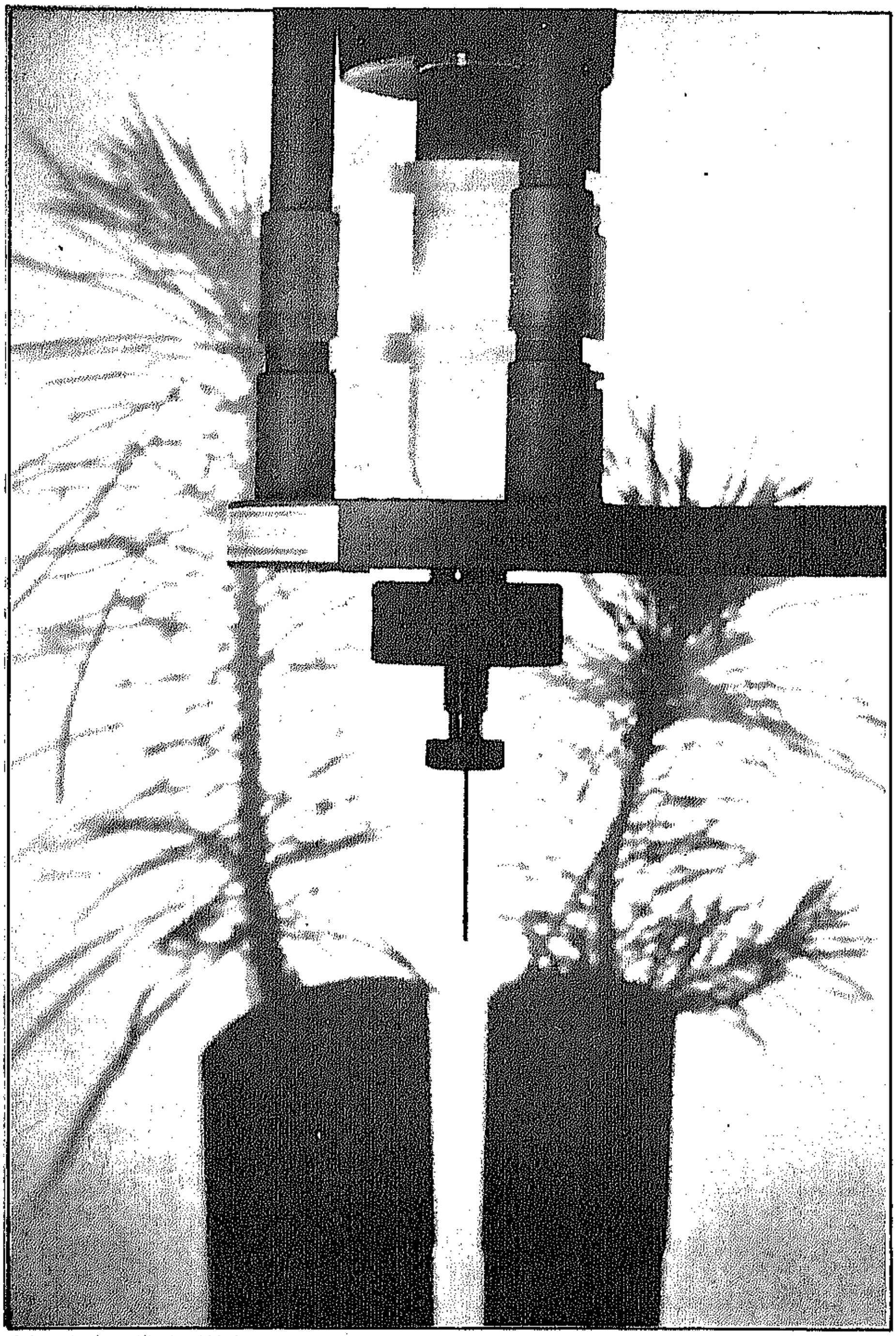
Somaclonal techniques are currently being evaluated at the sister program of the Institute of Forest Genetics Research, a Forest Service Laboratory in Rhinelander, Wisconsin, operated by the North Central Station. There, researchers are trying to select the major resistance gene to septoria canker in poplar, as well as genes conveying tolerance to heat and high salinity.

At the Institute for Forest Genetics, it's the white pine blister rust gene that's of particular interest. Somaclonal techniques should be very useful in producing cell lines containing that gene. Ledig explains that because the fungal mycelia of blister rust invade sugar pine cells in culture, and resistance is expressed on the cellular level by a hypersensitivity reaction, it should be possible to select colonies of cells containing the blister rust resistance gene. The cells could then serve as a ready source of the gene while scientists try different methods to isolate it.

Implications

Techniques like DNA transfer, the regeneration of trees from cells (when that becomes a reality), and somaclonal selection, are certain to have a profound impact on the way trees are utilized as a natural resource.

But satisfying the commercial needs of the timber industries won't be the only effect the new technology will have in forestry. The preservation of endangered tree species and maintenance of gene diversity are goals of equal importance; and these, too, will benefit from the new genetics.



A band of purified DNA from sugar pine needles, which was concentrated in a cesium chloride density gradient, fluoresces under ultraviolet light. Decoding DNA and identifying its components help us measure variation.

Sederoff imagines that there may be genes that can save threatened species even within their natural range. "Damage caused to trees by such atmospheric pollutants as ozone is a serious problem; and there may very well be genes that can protect these plants from damage by this and other toxic compounds."

As for the conservation of genes, a task now delegated to remote plantations and seed banks, it will be possible, using recombinant techniques, to store genes in bacteria or cells virtually indefinitely. These libraries could then be tapped — but never depleted — by future scientists looking for new or unusual traits.

"In fact, says Ledig, "species preservation and gene conservation take on added importance now that recombinant DNA technology can be used to cut out and transfer foreign genes among species. For example a valuable gene from a non-commercial species can be inserted into a commercially important one, giving added incentive to preserving genes, populations, and species." Sederoff agrees, noting that "a gene from a tomato plant or a wild grain could suddenly become extremely valuable if it had properties that conferred an important advantage to a tree, and the reverse is also true — it will be critical to save all kinds of genes."

But as more and more plant scientists gain the skills of genetic engineering, who should be applying them to the needs of forestry? The private sector? Government?

"Government and universities must take the lead," insists Ledig.

"The government should promote the acquisition of basic information when that information is important for national security and the future of the country," adds Sederoff.

Sederoff also points out that if genetic engineering is to become a reality in forest genetics, "forest biologists will first need to acquire a much better understanding of the basic physiological and biochemical actions of genes that carry important traits." That, too, will be the role of basic research. "We will first need to understand the properties that go into creating a particular fiber for paper or for wood, then we must know the molecular details of those processes to obtain the foundation needed before we can attempt to improve trees in very precise ways. All this will require cooperation among scientists at all levels," says Sederoff.

Although forestry schools in the United States and Canada have begun to develop ties with departments of biology and molecular genetics, Ledig has observed that "dialogue has been difficult." He says that on the one hand, "most forest biologists are not conversant with recent advances in genetics," while on the other, "few established scientists in molecular genetics are willing to abandon their model systems to work on trees."

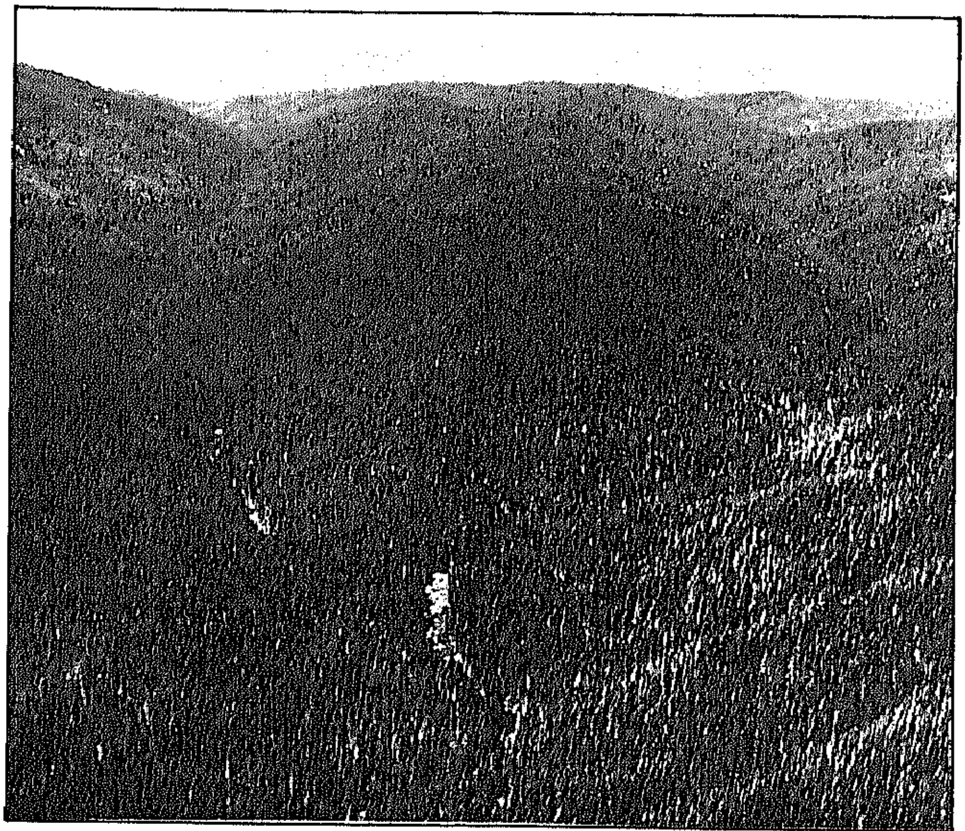
To help bridge this knowledge gap, the Institute of Forest Genetics has begun offering summer courses in recombinant DNA and tissue culture techniques to a small number of qualified researchers. "It's our missionary work," says Sederoff, only half joking." It's a first-of-its-kind effort to bring together government, the private sector, and academia for the promotion of forestry research.

The Institute of Forest Genetics staff have also established cooperative research programs with the University of California at Berkeley and Davis, and with Washington University in St. Louis.

The ultimate beneficiaries of the new biotechnology however, will be the public — the consumer and conservationist. Renewable resources will become more renewable. Trees that will grow faster or in marginal habitats would ensure a greater supply of wood and paper products. Sederoff forsees a forest industry that will become more like that of agriculture — specific trees for specific purposes. "The new biotechnology offers spectacular opportunities for improving forestry, and with the rate of technical advances we're seeing already, the options will soon be limited only by the imagination." Judging from the steps that he and others at the Institute of Forest Genetics have taken already, Sederoff's optimism does not seem exaggerated.

Below cost timber sales—viewing the forest, not just the trees

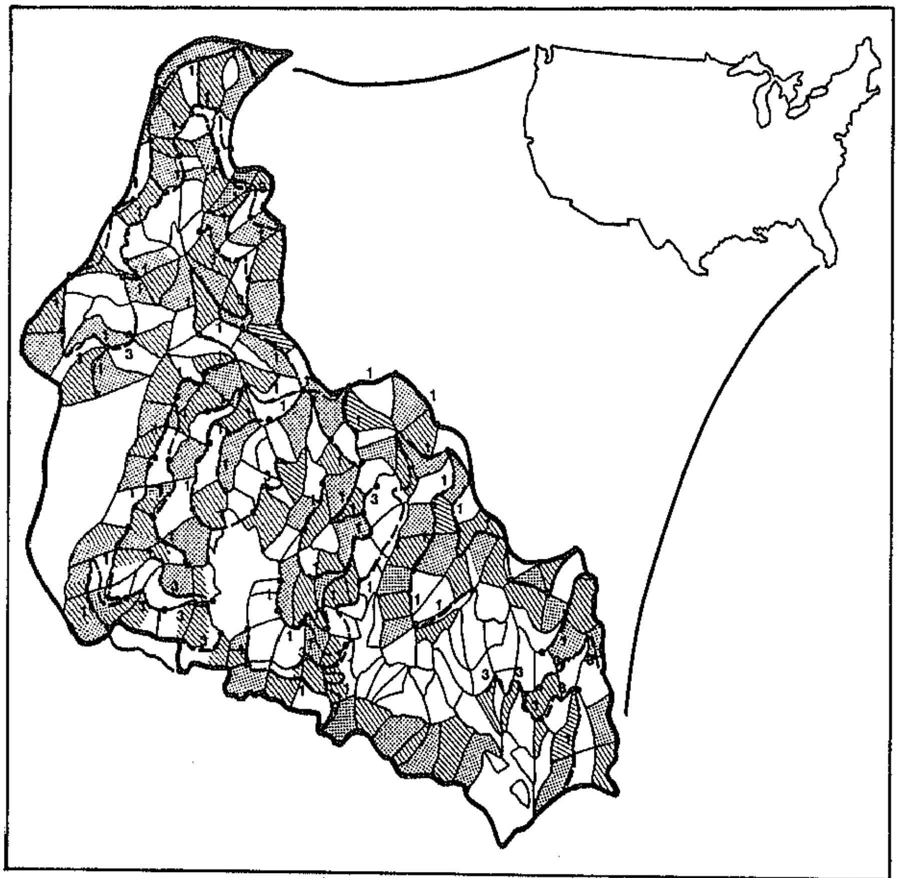
by Mike Prouty
Intermountain Station



Judging the merits of an individual timber sale solely on whether it generates dollars ignores the constraints and implications of managing for the multiple resources of a forest system.

The National Forest Management Act (NFMA), arising from the 1973 clearcutting controversy on the Monongahela National Forest, did more than establish legislative limits to clearcutting. By requiring Forest planning and economic analysis, NFMA increased the demand for, and elevated the status of, a breed of cat called forest economists — and their hi-tech tools of linear programming, such as FORPLAN. Thirteen years after Monongahela, this group is in the middle of another controversy surrounding harvesting timber on National Forests — the issue of below cost timber sales. And according to one Forest Service scientist, Project Leader Erv Schuster, the debate swirling around this issue has as much potential as Monongahela to change the way the Forest Service does business.

The "Multiple-Use Economics" research work unit (RWU) that Schuster heads is located at the Intermountain Research Station's Forestry Sciences Laboratory in Missoula, MT. Its mission is "to develop information, methodology, and models needed to better integrate analyses of economic efficiency and economic effects into forest resource management decisions on public forest lands."



Area-level analysis will help ensure that individual timber sales are planned to meet broad management objectives contained in Forest Plans.

Project economists investigate a wide range of questions, but recently their attention has focused on publications related to the economics of timber sales. Their message is clear and well documented: below-cost timber sales must be viewed within the context of the agency's total mandate. In fact, for the Forest Service to carry out the policies of nondeclining even flow, and integrated, multiple-use management as dictated by NFMA and prescribed in individual Forest plans, below-cost timber sales may be legitimate, if not essential.

Schuster is a strong advocate. He's not deterred by the unpopularity of his position, in light of the emphasis on government to turn a profit. If anything, he's spurred on to contribute facts to the debate, so that decisions are not made that defuse the issue in the short term only to cause the Forest Service a longer term headache.

Schuster is to the point. "We need to understand the implications of managing National Forests as an integrated system. Our agency's practices and products should be judged on the basis of the managerial context in which we operate. We must explain our behavior in terms of accomplishing objectives set forth in integrated forest plans over time. These plans provide the unifying logic behind what may seem like illogical ideas, if stated separately. The Forest Service has multiple missions, so we adopt a plan of attack for the whole outfit. We make tradeoffs in specific functions for the advantage of the total program."

An analogy

Schuster compares the National Forest System to a university in explaining his perception of below-cost timber sales. Both organizations have multiple missions and a systems perspective. A university is expected to teach, to conduct research, and to provide service. The National Forest System has a mandate to provide wood, water, wildlife, minerals, recreation, wilderness, and forage. In reviewing the adequacy of a university's program, a discussion of its research program cannot be held independent of its teaching and service missions. Good research generally makes faculty more productive teachers and teaching helps focus research, and both enhance the service function. They are interrelated, like parts of a system. Likewise, a review of the Forest Service's timber harvest program cannot be conducted without discussing how that program alters and is altered by other management considerations such as providing wildlife habitat, water quality, and recreation.

The same analogy helps explain Schuster's idea of how individual timber sales must be viewed. Should every class offered by a university be required to pay its own way? Of course not, maintains Schuster. Everyone knows the large, undergraduate classes are the "big buck" classes. More intensive upper level undergraduate and graduate classes with smaller enrollments may never pay their way. But a dean of a forestry school never decides to offer an individual course based entirely on its own merit. He views the course in terms of the total program of instruction as well as meeting mandatory constraints, such as maintaining accreditation by the Society of American Foresters. The dean that bans all classes with an enrollment of less than 25 students may be well-intentioned, but doesn't understand he's working in an integrated system. "It's these small, personal classes that give a school its flavor and curricular diversity" says Schuster.

Should every timber sale offered by the Forest Service be required to pay its own way? Like a university class, the answer is no. Some sales will generate revenue—the big undergraduate classes of the Forest Service. The agency is charged to provide recreation, to maintain or increase wildlife habitat, to protect water quality and scenic values, and to provide a nondeclining even flow of timber. An individual timber sale and its associated road construction may be below-cost because it is used to increase long-term recreation opportunities, to increase forage, or to provide an even flow of timber. Added costs may be entailed to minimize the effect of logging and road construction on water quality and scenic opportunities the forest provides. Like the intensive, but expensive graduate classes, it's the other resources like recreation and wildlife habitat that give the Forest Service its own special flavor, says Schuster. To look at an individual sale and judge its merits solely on whether it generates dollars may be well-intentioned, but it ignores the constraints, and the implications of managing a timber harvest program in the context of an integrated, long-term management of a forest system.

"If I hand you only one piece of a jigsaw puzzle, I defy you to describe the picture the puzzle creates, let along judge the worth of that puzzle piece," says Schuster.

Backing up the story with facts

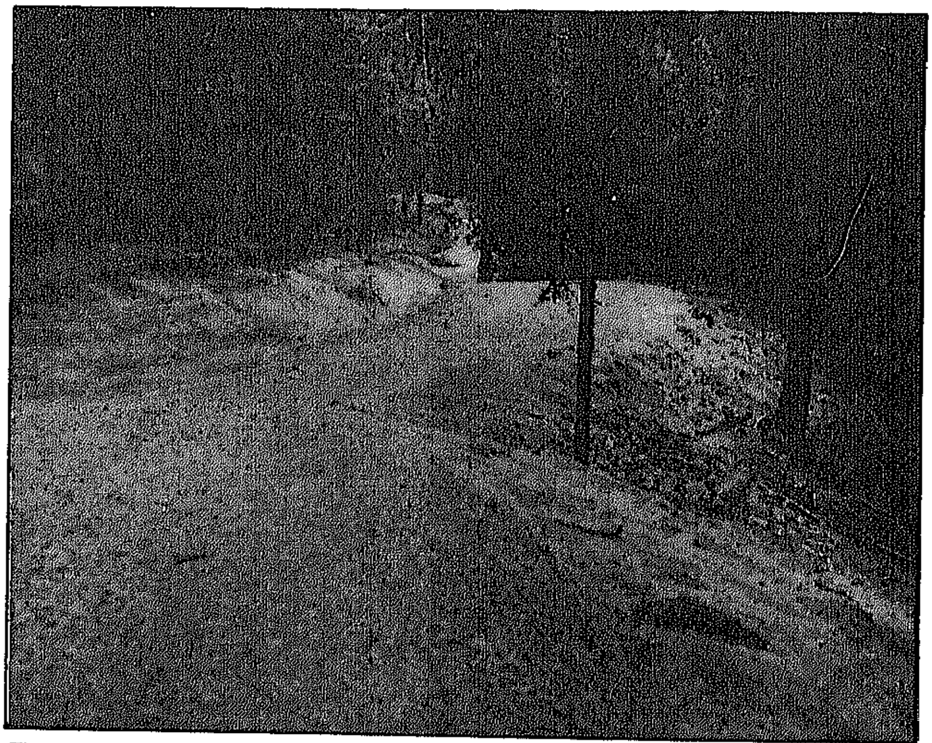
But Schuster and members of the economics unit do more than spin clever analogies. They conduct research—and the series of resulting publications that document the results of their work has shaped their stand on this issue, and has provided the technical basis for it.

Three publications—*Below-Cost Timber Sales: Analysis of a Forest Policy Issue,* by Schuster and Greg Jones (General Technical Report-INT-183), *Four Analytical Approaches for Integrating Land Management and Transportation Planning on Forest Lands,* by Jones, James Hyde, and Mary Meacham (Research Paper-INT-361), and *Costs of Managing Nontimber Resources When Harvesting Timber in the Northern Rockies,* by Bob Benson and Mike Niccolucci (Research Paper-INT-351)—provide the facts behind the stories.

The first publication stems from the need to analyze below cost timber sales within the context of efficient management resulting from coordinating timber and transportation planning within an integrated land management plan. Through a series of computer models, Schuster and Jones found that the net revenue from timber sales dropped markedly as the optimal pattern of roads and timber harvests was subjected to increasing constraints and restrictions dictated by multiple-use objectives and management.

They also found that the time reference in which a sale is viewed directly affects its status as "below cost." If the entire cost of permanent roads associated with a single sale is billed to that sale, its chances of being below cost are high. A more correct view, according to the report, is to evaluate the costs of the road both in terms of sales accessed today and other future sales its construction makes possible, along with those cost savings.

Finally, the researchers found that including benefits other than timber receipts will reduce the likelihood that a sale will be below cost. Although benefits other than timber dollars—such as increased recreation potential or improved wildlife habitat—are difficult to measure, they need to be considered because they were management objectives that influenced the planning, design, and administration of the sale. In short, the publication provides evidence that a sale can be made to appear in the black or the red merely by the accounting and analytical procedures used.



Roads associated with individual timber sales should be viewed as part of integrated, long-term management of forest systems.

The second publication addresses the problem of linking individual sales to broad management objectives contained in Forest plans. These plans were built to establish long-range, integrated management on millions of acres of forest. Ensuring that individual sales of a few hundred acres are planned and designed so as to incrementally achieve broad Forest-wide objectives is an ambitious task, and one that demands sophisticated computer modeling, mathematics, and statistics. This area of work, termed "area-level analysis" represents a major line of research, and is the specialty of Research Forester Greg Jones.

In his study, Jones tested several approaches to area-level analysis, varying in complexity, to link individual sales with Forest plans. He tested these computer models by using data from three large timber sale planning areas in western Montana and northern Idaho. Jones found significant differences in the ability of the four approaches to maximize the net revenue of the sale areas while keeping within broad management planning constraints. He also found that the effectiveness of the four computer models varied with the type of timber sale planning area.

'chuster sees Jones' work as tical. "The game has changed ice Forest plans became reality. There has always been a good planning procedure at the timber sale level, but now we really need a way to link this effort so that we're sure we're doing what we say we are going to do in our Forest plans. Area-level analysis will become increasingly important as more Forest plans are completed and the Forest Service begins to monitor on-the-ground compliance with these plans. They're going to need a way to do that, and this research is geared to providing reliable tools for that job."

The last publication resulted from a study designed to answer the questions, "How do timber sale requirements and objectives regarding soil and water, wildlife, recreation, and scenic quality affect the stumpage value of a sale? And how do these requirements affect the margin timber purchasers bid over and above the estimated stumpage value?"

To answer these questions, Benson and Niccolucci studied timber sales on National Forests in the Northern Region between 1975 and 1981. Their finding—it cost an average of $26 per thousand board feet in terms of reduced stumpage receipts to meet nontimber resource management concerns.

While the study answered some questions, it posed others to Schuster and his associates. How much of this cost of meeting nontimber concerns was going to merely preventing or repairing damage to nontimber resources? How much was going to actually improving the quality of these resources? Schuster, Niccolucci, and Research Forester Bob Loveless are now conducting another study to get a handle on these additional questions.

A glimpse of life in the pressure cooker

These publications result from research designed to address issues inherent in viewing the economics of individual timber sales within the context of the total Forest Service mission. Considering the heat of the debate, it is understandable that the research conducted by Schuster and his associates has attracted considerable attention.

The Below-Cost Timber Sales publication became almost required reading in Washington, DC, during Congressional hearings on this issue. Jones has traveled to DC to present seminars on the subject to top level administrators and legislators alike. Both Jones and Schuster have been asked to provide their perspective on this issue in a variety of forums.

But the limelight has not come without some pain. "Greg and I now know what life in the pressure cooker is like," says Schuster. "I don't ever want to go through the kind of pressure associated with publishing the Below-Cost paper under the kind of deadline we had. We're just flat lucky we had research already under way that provided information relevant to the below-cost issue when it hit. But now I think it's time we back off from the debate. If we get pigeonholed by taking sides we'll lose our credibility—and our effectiveness at providing information will be shot."

Schuster and the other scientists in his unit walk a fine line between dedicating their work to problems facing the National Forests while still keeping their credibility. But Schuster is proud of the contributions he and his associates have made. "We've been responsive. We've shown we're interested in helping solve problems. Maybe we've put a crack in the notion that researchers are nothing but a bunch of ivory tower snobs. I want the National Forest personnel to be our champions, and the only way to win their respect and support is to respond quickly and effectively to their information needs."

Helping Schuster and Jones respond quickly and effectively (they are the only permanent full-time personnel in the unit) is a cadre of dedicated young professionals Schuster describes as "the best in the world." Economists Jim Hyde and Mike Niccolucci, Research Forester Bob Loveless, and Statistician Mary Meacham are all on temporary appointments, but all play an integral research role. Research Forester Bob Benson and Computer Clerk Linda Deckard have recently left the unit, but Schuster is quick to acknowledge the contributions they have made.

A spectrum of activity

Where to now? Schuster and his associates have their fingers in dozens of pies—from quantifying the cost of managing for nontimber resources in timber sale planning, to assessing the viability of timber sales, to basic economic research on apportioning costs, to incorporating studies with those of other research work units involved in forest survey and growth and yield, to developing data bases that reflect shifting recreation use patterns, to developing methods of quickly meeting information needs of managers without conducting lengthy long-term studies.

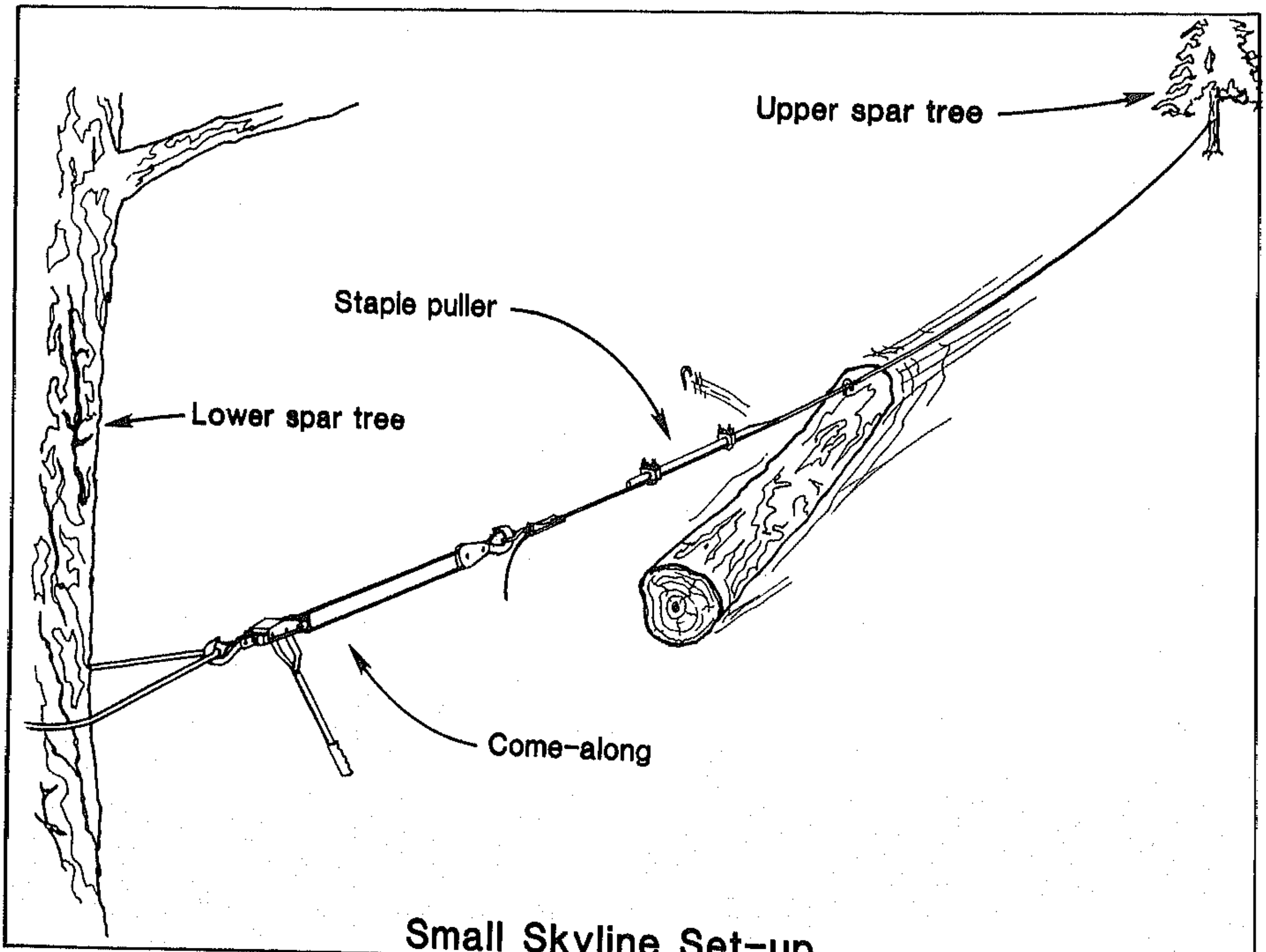
To each area of investigation, to each new study, Schuster and his associates impart their own distinctive brand of energy, as well as their economic and quantitative skills. And most importantly, the product of their labor is information that will provide forest managers with new methods of solving tough problems, a framework for addressing tough issues, and a management perspective that may serve to avoid future problems.

Reach for the skyline: news for firewood collectors

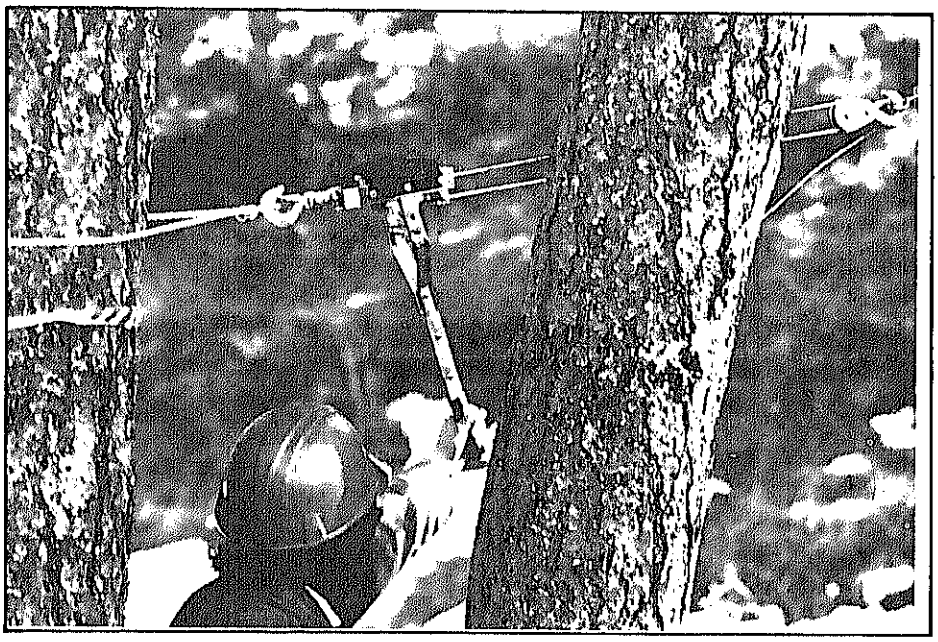
by Rick Fletcher
Rocky Mountain Station

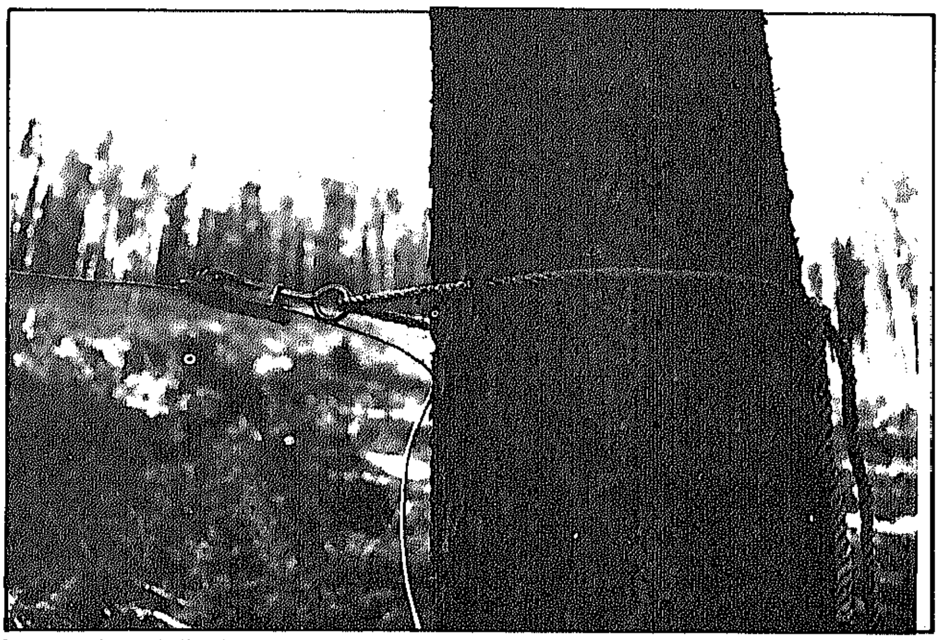
Firewood has always been an important source of energy in the United States. Until the 1880's it was our major energy source. However, by the turn of the century, fossil fuels and electricity began to come of age and the use of wood dropped dramatically. But now, due to fossil fuel prices, an increasing number of households are using wood as a primary or supplementary energy source for heating and cooking. The USDA Forest Service predicts that residential use of fuelwood will increase steadily from the 6 million cords used in 1976 to over 26 million by the year 2030. However, in many of the more populated regions of the West, easily accessible firewood is becoming more and more scarce. The dead material left by insect attacks, wildfires, and old timber sales, has all but been used up.

Although firewood programs vary from forest to forest, depending on the demand for and availability of firewood, little doubt remains among most foresters that additional collection areas are needed for the future.



Small Skyline Set-up





One end of the skyline is attached with a come-along that keeps the wire taunt (top). The other end is secured using a nylon rope and quick release wire grip (bottom).

Resource specialists have long realized that much wood remains inaccessible in areas above and adjacent to roads because the slopes are too steep to hand carry or drag firewood. New research at the Rocky Mountain Station has resulted in a simple, single-span skyline system that facilitates the harvest of fuelwood from such areas. Research Forest Products Technologist Don Markstrom explains that several small skylines have been devised in the past, but no specific literature is available on the engineering aspects of such skylines.

Testing

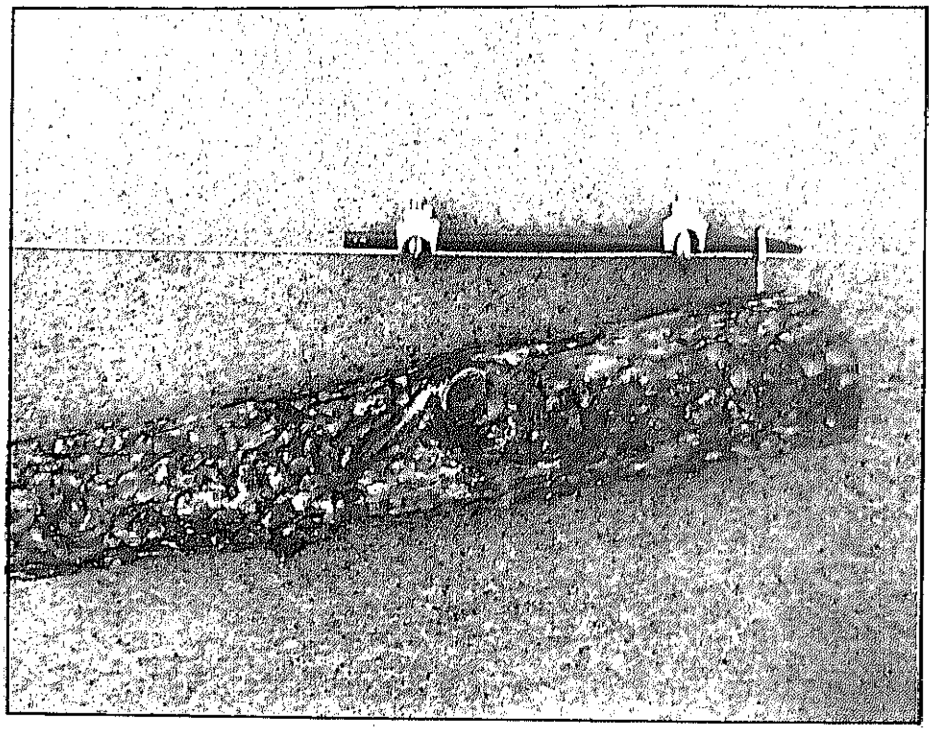
In 1984 Markstrom began testing a variety of small skyline components in various combinations in the subalpine forests of Colorado. "The first step in developing a skyline was to analyze the effects of firewood block weights and degrees of slopes on the maximum potential span of a single span skyline," he said.

A mathematical model of a cable hanging in a cantenary curve (the curve assumed by a cord or chain hanging freely from two non-vertical points) and an accompanying computer program were used to calculate the span. Markstrom explained, "Two types af skyline were modeled and tested, one with 1/8 inch wire cable with a breaking strength of 2,000 pounds, and a second with No. 9 wire estimated at 1,000 pounds. The skyline was attached to both upper and lower spar trees at a height af 5 feet - the maximum height considered reachable for attaching skyline wire to spar trees and hanging firewood blocks without a ladder."

One end of the skyline was attached to the upper or lower spar tree with a nylon rope and quick-release wire grip. The other end was attached with either a boat-trailer winch or a come-along winch that kept the skyline taut. The wire was attached to the winch cable by means of wire thimbles, clips, and a chain link.

The maximum allowable skyline lengths for different firewood block weights were computed using a computer program (Perkins. R.H., S.K. Suddarth, and E.W. Stark. 1969. A Computerized System for Engineering Design of Single-span Standing Skylines). For instance, the maximum length for sliding a 30-pound block down a 20 percent slope with No. 9 wire would be 153 feet. However, if more deflection due to less initial tensioning of the wire were allowed, then a skyline greater than 153 feet, or a block of more than 30 pounds, could be transported. "But the relation of the variables expressed by the model must be maintained," said Markstrom. "Initial tightening of the wire is important. If the wire is over-tightened, it could break under an otherwise safe load," he said.

Two fencing staples with one prong shortened with a wire cutter were driven into the firewood blocks. Once hooked onto the skyline, gravity transports them to the lower spar tree. Blocks are prevented from hitting the lower tree by attaching a staple-pulling device to the skyline, or by attaching tires to the tree.



A staple puller (top) or tires (bottom) can be used to keep firewood blocks from hitting the lower spar tree.

Skyline type	Firewood block weight, lbs.	Slopes, %	
		20	40
		-- maximum skyline span in feet --	
No. 9 wire	30	153	151
	50	92	97
1/8-inch wire rope	30	163	162
	50	102	97

[1]*The maximum skyline spans are calculated on the basis of midspan deflection of 2 feet and allowable tension load of 667 pounds.*

Calculated maximum skyline spans to slide firewood blocks of different weights down different slopes with wire or wire rope skyline.

Markstrom experimented with eight different combinations of skylines, firewood block weights, and slopes at the Fraser Experimental Forest in central Colorado. Tests included No. 9 wire and 1/8 inch wire cable skylines, 30- and 50-pound blocks of wood, and 20 and 40 percent slopes. There were no equipment failures for any of the tests. However, firewood blocks did not slide the complete skyline distance in all cases. On 20 percent slopes, blocks stopped 10 to 40 feet before the lower spar tree when 1/8 inch cable was tested. However, blocks traveled the full distance when No. 9 wire, wiped with an oil rag prior to the test, was used.

None of the skyline wires showed any significant visible wear. The staples holding firewood blocks to the wire cable skyline did, however, show wear, while staples used with the No. 9 wire showed no wear.

Application

"The bottom line," says Markstrom, "is that a single-span skyline made from No. 9 wire and other materials commonly available from farm and ranch or hardware stores is an effective method for moving firewood down slopes of 20 percent or greater."

The skyline can be fabricated using common handtools, and can be hand-carried to the skidding area and erected by two people in one hour or less.

A new publication, available from the Rocky Mountain Station, details this research and recommendations for safe use of the skyline. Request *Feasibility of Collecting Firewood with a Small Skyline,* Research Note RM 468. Additional information is available by contacting Don Markstrom, Rocky Mountain Station, 240 West Prospect Rd., Fort Collins, Colorado 80526, (303) 224-1879, FTS-323-1879.

Component	Cost (dollars)
300 feet of galvanized No. 9 merchant wire	7.50
2-ton come-along winch	15.00
1 1,500-lb. quick release wire grip	7.50
1 staple-pulling device	2.50
2 1/8-inch wire thimbles	1.50
4 1/8-inch wire clips	2.50
30 feet of 3/8-inch nylon rope	7.00
2 chain links	6.00
5 lbs. of 2-inch staples	3.00
Total	52.50

A listing of components and approximate costs for skylines comparable to those tested in the study.

Matching seed to site assists productivity

by Dorothy Bergstrom
Pacific Northwest Station

The Douglas-fir seed orchard of the Dallas Cooperative is 4 years old. When tree are about 12 feet tall, the best trees in each family of crosses will be lifted and moved to another location to form an instant seed orchard of maplike design.

Seed zones are changing size, seed orchards are becoming more sophisticated, and seed transfer rules are being revised on the basis of new information about the genetic adaptation of forest trees to certain environmental conditions. Matching seed to site requires more precision and is more important to forest productivity than anyone thought possible when seed transfer zones were established in 1966.

The word from geneticists is that planting trees that are genetically adapted to conditions of the planting site is just as important as planting "improved" seed to get trees that will grow bigger faster. If seedlings are not adapted to the planting site, they will not grow vigorously, or they may succumb after 40 years to unusually severe weather or to pests their genetic makeup has not prepared them to resist.

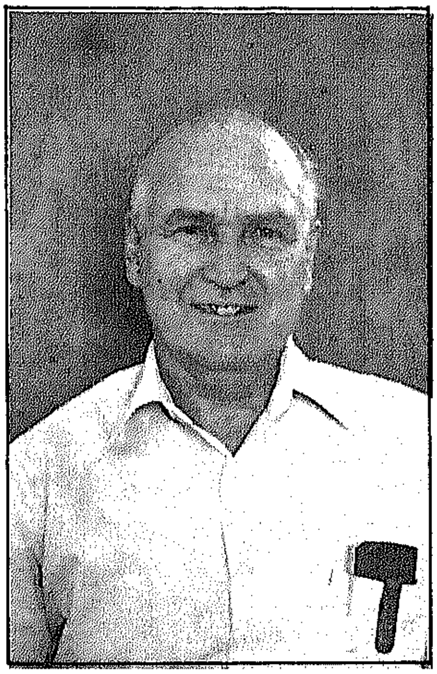
Intensive sampling has helped geneticists refine the relation between inherited tree traits and environmental conditions.

For several wide-ranging species like Douglas-fir, western hemlock, and ponderosa pine, the genetic makeup is probably as varied as the forest environments of the Pacific Northwest, an area that may have more environmental variation in one county than whole States have in the eastern part of the country.

The new information will help forest managers with one of their most important jobs: selecting the correct seed for reforestation. Foresters can now choose seed that both is adapted to the growing site and offers gains in productivity. And they can do this without spending more money.

The new information comes from the genetics research unit of the Pacific Northwest Station's Forestry Sciences Laboratory in Corvallis, Oregon. Roy Silen, leader of the genetics unit for more than 30 years and now a part-time volunteer scientist, says, "When one of our geneticists discovered how precisely trees are adapted in one small watershed in the Oregon Cascades, we were shocked at the forestry implications—shocked because the findings implied that there was as much variation within our established breeding zones as between zones."

Breeding zones for Douglas-fir were established in the mid-1960's to help forest managers select seed for reforestation when it was not available from the local area. In 1966, a seed zone map for Oregon and Washington was published by the Western Forest Tree Seed Council. The map divided the States into regions of similar physiography and climate, based on what was then known about moving seed in elevation and from north to south and east or west of the Cascades. The theory was that seed from anywhere within a zone could be safely used for reforesting any site in the same elevation band of the same zone. Geneticist Bob Campbell, a colleague of Silen at the Pacific Northwest Station in Corvallis, was on one of the committees that prepared the map. He says the map was quite subjective because little was known about patterns of genetic variation or about environmental factors. Compared with other forest regions of the world, the typical Pacific Northwest seed zone was considered small.



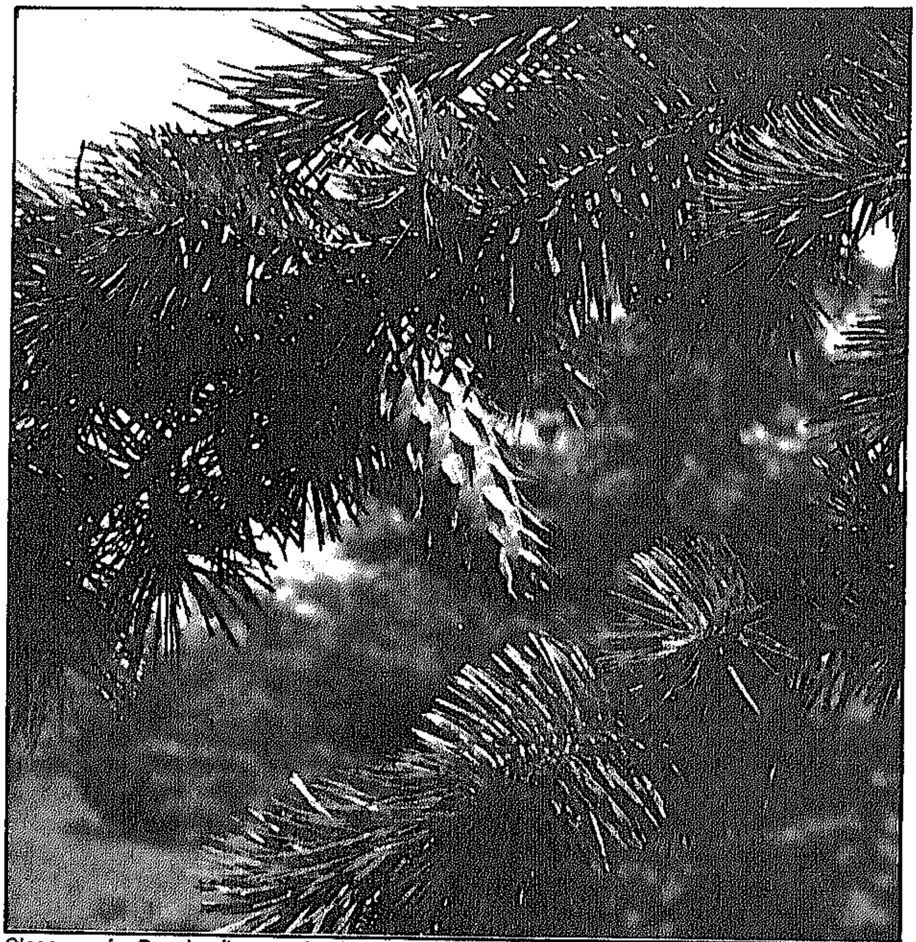
Geneticist Roy Silen.

Geneticists studied seedlings

Geneticists have now statistically related inherited characteristics, like frost susceptibility; germination rate; and times of budset, budburst, flowering, and pollen release; to the environmental variables of growing sites. These include elevation, latitude, longitude, distance from the ocean, degree of slope, aspect, amount of sunlight and precipitation, temperature of air and soil, fertility of soil, location of frost pockets, height of slope on which trees grow, and vertical distance from the bottom of a drainage. The inherited traits determine how well trees will survive under local environmental conditions and adapt to seasonal weather patterns to grow in height and diameter and compete with neighboring plants.

Campbell was the geneticist who made the study that Silen says had shocking results. He sampled a small watershed much more intensively than had been done before. The data came from seedlings grown from the seed of 190 Douglas-fir trees in 114 locations in a 400-year-old stand on the west slope of the Cascade Range. When the seedling families were 3 years old, Campbell estimated genetic variation on the basis of 15 traits that included height, diameter, seed weight, germination rate, and time of budset. He found that 10 to 42 percent of the variation in traits could be explained by location of the parent trees. Of this source variation, elevation alone explained about 56 percent, and habitat type accounted for about 35 percent. When lines were drawn on a map to link the locations of tree parents of seedling families of equal height, they mimicked a topographic map of the drainage and showed a template-like match between the environment and the genetic response.

Lack of adaptability to site is often referred to as "degree of risk in seed transfer." The risk is in two possibilities that may lower the productivity of the stand. Seedlings may grow poorly on sites they are not suited to, or the sites may not allow them to live up to their genetic growth potential. The degree of risk is correlated far more with the "environmental distance" seed is moved than with geographic distance. The obvious success of seed transfer over long geographic distances is illustrated by the good adaptation of species from the Western United States to appropriate environments in Europe,



Close up of a Douglas-fir cone that has been pollinated and is developing seed in the Molalla orchard of 11-year-old trees.

Australia, and New Zealand. Yet, transfers over short geographic distances in the same watershed have resulted in stand failures when "environmental distances" were large, as when changes in elevation or available moisture were substantial.

Frank Sorensen, another geneticist on the Pacific Northwest Station staff, worked with Campbell on a study that sampled 40 populations of Douglas-fir from seed collected between the Pacific Ocean and the crest of the Cascade Range between 42° and 48° N. They concluded that the risk is greater in moving Pacific Northwest provenances east-west than north-south and that the risk increases with elevation. They also found that north-south transfers are more critical near the coast than inland.

In a study of Douglas-fir from four elevations on the west and east aspects of the first and second ridges inland from the Pacific Ocean—a distance of only a few miles—Sorensen found a pattern of genetic variation adapted to moisture and temperature regimes. Seeds from the east aspects of the both ridges were larger and germinated faster than seeds from the west aspects. Plants from the east, or inland, aspects tended to start and end elongation of leaders earlier and have smaller top-to-root ratios compared with plants from west aspects. The differences between the two aspects of the coastal ridge were generally greater than those between the two sides of the inland ridge. Changes associated with elevation were greater on the coastal ridge than on the inland ridge. Length of the growing season and heat accumulation changed more with elevation and latitude near the ocean than inland.

Sorensen also studied the inland variety of Douglas-fir (*glauca*) east of the Cascades to determine whether the change from the western variety (*menziesii*) was abrupt or gradual. Seed was collected between 44 and 45 degrees N., from the Cascade summit to the Blue Mountains summit. Distance east of the Cascade summit and elevation accounted for 85 to 94 percent of variation in growth. The most abrupt transition was within about 150 miles of the summit of the western Cascades. Sorensen concluded that an average 1,000-foot difference in elevation had about the same effect as a west-east shift of about 17 miles.

His findings suggest that seed transfer should be more restricted at high elevations, the same observation he and Campbell had made about Douglas-fir in western Oregon and Washington. In fact, Sorensen recommended only natural regeneration for high elevations east of the Cascades.

In a study of Douglas-fir in southwest Oregon, Campbell found strong gradients associated with elevation, latitude, distance from the ocean, slope, and sun exposure. He concluded that risks in moving seed were greatest when seed was transferred either east or west along the southern boundary of the study region or north and south along the eastern boundary. The gradients in risk were consistent with the steepest gradients of precipitation and temperature.

Confirming data comes from older progeny

Since Campbell and Sorensen's work with seedlings in a nursery with regulated environments first indicated that adaptation is much more precise than was understood when large-scale reforestation was begun, reinforcing information has come from somewhat older trees. A large amount of data is from the 600 progeny test plantations in western Oregon and Washington that have been planted as phase I of the Progressive Tree Improvement Program and include the families from 25,000 parent trees.

This program was conceived by Silen in 1966 to help get better seed for reforestation without depending on grafted seed orchards. Under the supervision of Joe Wheat, who for many years was director of the Industrial Forestry Association, the program was adopted by tree-improvement cooperatives and now covers 8.5 million acres of public and private forest land in Oregon and Washington. Essentially, the program requires selecting superior-appearing mature trees and conducting large-scale tests of their ability to pass on to their wind-pollinated progeny certain important characteristics, such as growth, good form, and resistance to disease.

Seedlings from each parent tree are planted in families and measured every 5 years for growth and survival. The typical test plantation provides data on 100 progeny per parent tree on 6 to 12 sites. Testing of more than 25,000 parent trees has required regular measurements and analysis of more than 2 million tagged seedlings.

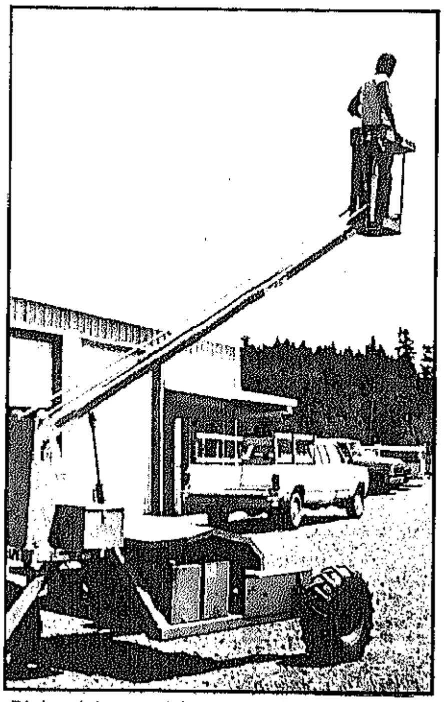
When Silen reviewed measurements made when trees in the two oldest cooperatives were 10 and 12 years old, he found considerable variation in height that was correlated with the location of parent trees. Within breeding zones about the size of a county, the patterns of progeny height displayed complex gradients, or clines, that conformed to major landforms of valleys and ranges. In one cooperative, a 1,000-foot difference in elevation of parent tree, or a 10-mile shift of location east or north, meant a 15-percent difference in family volume growth.

Silen mapped this genetic variation as a series of six parallel bands, each differing by 2.5 percent in height growth. In a subsequent review of data from the progeny tests of four more cooperatives, Silen found similar banded patterns of height based on the location of parent trees.

After mapping tree heights for all six cooperatives, Silen concluded that a 10- to 15-percent difference in family average height, or a 30- to 50-percent difference in volume growth rate, was associated with geography. Mapped height lines corresponded with topographic features best where sampling was most dense. One example of this was at the edge of the Willamette Valley, where there was an average difference in height growth of about 15 percent between the slow-growing trees bordering the droughty Willamette Valley and trees a few miles west in the more moist Coast Range.

Implications of more precise adaptation

In the past, the aim of tree breeding was to develop fast-growing tree populations adapted to a broad range of environments. This aim was probably impractical because it would have required long periods of testing parent trees. Now, as a result of the newer findings, the simpler and more practical aim is to perpetuate and conserve the genetic structure of local natural stands and to select the faster growing individual trees as parent trees.



Richard Jaeger, labor supervisor at the J.E. Schroeder Seed Orchard near Woodburn, Oregon, demonstrates the "orchard ape," a lift that extends 20 feet in height and can be operated by one person to help with several operations, including pollinating flowers and picking cones. The orchard is operated by the Oregon Department of Forestry.

Providing seed more closely adapted to particular environments is becoming practical because of recent changes in the design of seed orchards. At the J. E. Schroeder Forest Tree Seed Orchard, operated by the State of Oregon Department of Forestry, innovations to take advantage of new knowledge about adaptation were put into practice by Jack Wanek, who was tree-improvement coordinator and supervisor of the orchard until his recent retirement. Four of the eight second-generation seed orchards are now producing seed.

Seed orchards were started as part of the Progressive Tree Improvement Program in 1973, with seedlings from single-pair matings of the original parent trees. All eight orchards under Wanek's supervision were established soon after the progeny tests were begun. The plan is to improve the seed orchards gradually by roguing poor-performing crosses as information about the seedling families is provided by the progeny tests. Progeny trees are rated on several traits. Height counts most but straightness, lack of forking, and lack of stem defect also count.

The most recently established orchards—whether Douglas-fir, western hemlock, or other Northwest species—are planted in a maplike arrangement that relates the location of seed trees within the orchard to the location of the parent trees within the breeding zone. The maplike locations of progeny in the orchard reflect the clines of increasing cold, increasing drought, and increasing elevation that are found in Pacific Northwest forests west of the Cascades. Members of the same tree family are planted within the same block, instead of being distributed randomly throughout the orchard, although individuals of the same family are separated to prevent inbreeding. The structured layout means that pollen will be exchanged among trees adapted to the same forest conditions. It also means that seed selection from the orchard can be much more precise. Seed can come mainly from local families or from a mix made from families in an orchard band adapted to environmental conditions at the intended planting site.

Conclusion

The new design of seed orchards and a greater understanding of genetic adaptation will help forest managers do a better job of reforestation, and, by selecting seed more precisely suited to planting sites, the managers will help conserve the genetic structure that has been shaped over millions of years. The forests of the Western United States remain more nearly the product of natural selection than forests in parts of the world that have been settled longer. Silen says, "Because of several fortunate turns of history and geography, we have a remarkable heritage of forest trees. If we make modest refinements by using seed from faster growing trees and plant it where it is adapted to grow, we will be helping to pass on our heritage."

Silen has written several nontechnical articles about forest genetics that are available in libraries. They include "The Care and Handling of the Forest Gene Pool," which appeared in *Pacific Search* (name changed to *Pacific Northwest*) for June 1976, and *Nitrogen, Corn, and Forest Genetics*, General Technical Report PNW-137. *Forestry Research West* has carried related stories: one about the tree improvement program (November 1979) and another about improving the yield of Douglas-fir (March 1983).

However, a recent survey on one National Forest in eastern California showed that not enough large (more than 40 cm dbh) snags were being retained away from water and forest openings.

Researchers do not indicate that similar conditions may exist on other forests. They do, however, suggest that surveys should be an important priority before removing standing dead trees, especially in eastern Sierra Nevada forests.

Further details on this study, along with management implications, are, available in the reprint Snag Requirements of Cavity-Nesting Birds: Are USDA Forest Service Guidelines Being Met?. The Rocky Mountain Station has copies.

Timber guidelines for the Central and Southern Rockies

A new series has just been published by the Rocky Mountain Station that provides guidelines for forest managers and silviculturists overseeing spruce-fir forests in the central and southern Rocky Mountains, and Front Range ponderosa pine and lodgepole pine in the central Rocky Mountains.

The three reports offer suggestions on developing even- and/or uneven-aged cutting practices for converting old- and mixed-growth stands into managed stands for a variety of resource needs.

Guidelines consider stand conditions, succession, windfall risk, and insect and disease susceptibility. Suggested cutting practices are designed to integrate timber production with increased water yield, maintained water quality, improved wildlife habitat, and enhanced opportunities for recreation and scenic values. Details are in the following reports, available from the Rocky Mountain Station: *Silvicultural Systems and Cutting Methods for Old Growth Spruce-fir Forests in the Central and Southern Rocky Mountains*, General Technical Report RM-126; *Silvicultural Systems and Cutting Methods for Old Growth Lodgepole Pine Forests in the Central Rocky Mountains*, General Technical Report RM-127; and *Silvicultural Systems and Cutting Methods for Ponderosa Pine Forests in the Front Range of the Central Rocky Mountains*, General Technical Report RM-128.

Study shows how to predict effects of thinning and overstory removal on red fir advance regeneration

Advance regeneration is common under old-growth stands of California red fir (*Abies magnifica*). Intense competition for the site's resources can create sapling stands of poor vigor and advanced age. When competition is reduced by overstory removal and thinning, suppressed advance regeneration often responds with increased growth.

But, to select leave trees, land managers need to know which tree characteristics are associated with growth after release and thinning. This paper reports those easily measured tree characteristics found to be most closely associated with growth after 8 years, on the Swain Mountain Experimental Forest in northeastern California.

After treating ten acres, saplings with a variety of stem and crown characteristics were monitored. Although reliable equations to explain growth were not developed, scientists indicate that PLC (percent live crown) may serve as a rough guide for selecting leave trees.

Sample trees with PLC of 40 or more suffered less postrelease damage and responded with increased rates of growth. Mortality and damage, rate of healing of wounds, recent snow bend, and sunscald were all variously related to smaller PLC's. Choosing the best advance regeneration shortened the rotation length for the next crop by about 12 years compared with post-harvest regeneration.

Further information is contained in *Growth of California Red Fir Advance Regeneration After Overstory Removal and Thinning*, by William W. Oliver, Research Paper PSW-180, available from the Pacific Southwest Station.

Wildlife on the range: two new publications in the Great Basin series

Each publication in the Pacific Northwest Research Station's series *Wildlife Habitats in Managed Rangelands—the Great Basin of Southeastern Oregon* is intended to provide specific information for a particular area, and to develop a process for considering the welfare of wildlife when range management decisions are made.

In *Management Practices and Options,* author Frederick C. Hall (regional ecologist for the Pacific Northwest Region, USDA Forest Service) notes that careful juggling of a complex series of biological, economic, legal, and social tradeoffs is necessary for effective simultaneous management of livestock and wildlife in the Great Basin.

At least for the present, livestock grazing is the dominant use of these lands. Thus the manager's task is to determine how to manage livestock and manipulate vegetation cost-effectively for enhanced livestock production, with minimum detriment to—or, if possible, with a positive impact on—wildlife habitat.

Land managers have both opportunities and constraints to consider when formulating management objectives and alternatives. In general, no matter what the manager does or does not do, the habitat of some species of wildlife will be enhanced and that of others diminished. Laws regulating management of public lands require that these effects be considered and evaluated when management decisions are made.

This publication deals primarily with livestock management in relation to wildlife and wildlife habitat. Included are discussions of ecological status (range condition compared to what would occur without fire or livestock grazing: the 'potential natural community'), livestock management, diversity, and multiple-use options for each species featured in previous chapters (trout, sage grouse, pronghorn, mule deer, and bighorn sheep).

For more information, request *Management Practices and Options,* General Technical Report PNW-189.

Another newly released publication in the same series is *Sage Grouse* by Wildlife Management Consultant Mayo W. Call and Bureau of Land Management Research Wildlife Biologist Chris Maser.

Survival of populations of sage grouse—a habitat-specific bird that relies primarily on sagebrush to meet its life requirements—depends on maintenance of essential habitat components to meet the seasonal needs of grouse. Call and Maser discuss an array of habitat components and provide some specific management tips designed to help perpetuate quality habitat for the grouse. They define cover and forage components of optimum sage grouse habitat and describe how changes in plant community structure and composition affect habitat quality.

Although optimum habitat for sage grouse may not always be maintained because of other resource uses, compromises to meet the needs of the grouse are possible. Their intent, say Call and Maser, is to help rangeland managers evaluate habitat manipulation in terms of impacts on sage grouse populations and the tradeoffs available.

Sage grouse densities in the Great Basin vary, depending on the subspecies and structure of the sagebrush, composition and density of the understory vegetation, intensity of livestock grazing, presence of water, and human disturbance.

In discussing the relation of management to breeding, nesting, brood rearing, and wintering habitats, the authors note that sagebrush control—whether mechanical, chemical, or by fire—may increase or decrease the desirability of the traditional strutting grounds.

The effect of sagebrush control is also particularly important on sage grouse winter range because sagebrush is practically the only food the birds eat in winter. If adequate food and associated cover are no longer available, the grouse are forced to abandon such areas. Specific management of the effects of fire, livestock grazing, and human disturbances is also important for maintaining sage grouse habitat.

Where sage grouse are to be managed as a featured species, their primary habitat requirements need to be identified, and habitat maintained or enhanced to meet those needs. Call and Maser offer tips designed to help a manager achieve this goal by managing vegetation and livestock, water developments, and fencing; controlling visitors and vehicle use; and using prescribed fire.

Fire, properly applied, can be used to perpetuate the structural conditions in the types of habitat needed by sage grouse. A major objective of using fire for habitat improvement is to produce a diversity of habitat types, both in terms of food and cover. Planned fire can produce favorable openings and higher

yields of forbs for grouse in summer habitat, but it is not favorable in winter habitats, where retention of sagebrush is essential.

Ultimately, sage grouse can benefit from range management, but only if their welfare is given advance planning, and meeting their habitat requirements is no longer left to chance.

For more information, request *Sage Grouse*, General Technical Report PNW-187.

Guidelines available for testing insecticides on coniferous forest defoliators

Coniferous forests in the West are periodically infested by epidemic populations of defoliating insects. One method of control, effective and safe use of insecticides, is an integral part of most pest management programs. But variations in the persistence of chemicals, vulnerability of insect species and/or populations to chemicals, relationship of vulnerability to developmental stages of the insect, weather conditions, forest type and stand structure, dosage rates, spray nozzle systems, aircraft types, and other factors complicate the evaluations of insecticides.

Based on experiences with Douglas-fir tussock moth and western spruce budworm in Washington, Oregon, Idaho, and Montana, with the latter species in the Northeastern US, this report provides a guide to testing insecticides applied to coniferous forest defoliators. It outlines techniques for designing, installing, conducting, and evaluating various types of projects, and describes the sampling considerations, methods, and analytical methodology necessary to do the job.

For further information, request *Guide to Testing Insecticides on Coniferous Forest Defoliators,* by Carroll B. Williams, Jr. et.al, General Technical Report PSW-85, available from the Pacific Southwest Station.

Regeneration evaluated in clearcuts, partial cuts

A new publication from the Pacific Northwest Research Station, *Regeneration Outlook on BLM Lands in the Siskiyou Mountains* by William I. Stein, combines with a previous report (Research Paper PNW-284 (Stein, 1981)) to provide a comprehensive, detailed evaluation of forest regeneration resulting from past silvicultural practices on the Medford District. In the publication, Stein calls for better use of existing information and experience, and for a more flexible, site-specific approach for harvest system selection and postlogging treatments.

A survey of timberland cut over from 1956 to 1971 in the Applegate, Evans, and Galice-Glendale areas of southwestern Oregon showed that both partial cuts and clearcuts were well stocked with a combination of regeneration (primarily Douglas-fir) that started before and after harvest cutting. All three geographic areas have a substantial range in elevation, well-dissected terrain, mostly moderate to deep soils, and similar growing seasons and temperature patterns. All are inland areas with some rain shadow effects from adjacent higher ridges and peaks.

The study indicates that average stocking differed significantly by forest type, soil series, soil origin, soil depth, and stream drainage, and correlated with an array of environmental variables.

Correlations based on stocking data from individual areas accounted for the most variation. Those based on forest types were second, and those based on the geographic areas combined were lowest. In both partial cuts and clearcuts, stocking usually decreased as slope increased; as the amount of seedbed covered with logs, wood, and bark increased; and as the cover of woody perennials increased.

Regression equations describe present stocking patterns, and other equations predict future stocking based on variables that can be observed or specified before harvest.

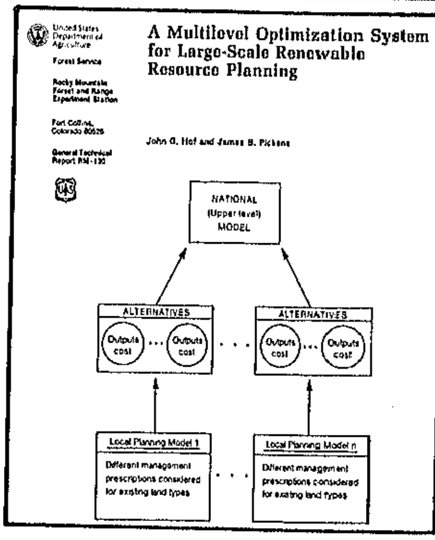
According to Stein, who is principal plant ecologist at the Station's Forestry Sciences Laboratory in Corvallis, Oregon, reforestation can be improved by paying greater attention to forest type, soil series, site conditions, and differences in plant communities when selecting harvest method and reforestation techniques.

"The single most important thing forest managers can do to minimize difficulties in obtaining artificial regeneration is to reforest cutover areas promptly," he says, noting that tending the developing stands in a timely manner is critically important.

Stein identifies a variety of opportunities for administrative studies or research to enhance reforestation efforts. Ecological studies to better understand existing stands—their nature, origin, and successional trends could provide valuable insight for managing these mixed stands, and might indicate how to work in concert with nature rather than in opposition.

The studies suggested are based on the premise that reasonably intensive management—with timber production as a primary objective—will be practiced, he says, adding that their relative importance would change markedly if management objectives were substantially different.

For more information, request *Regeneration Outlook on BLM Lands in the Siskiyou Mountains,* Research Paper PNW-349.



A method for large-scale renewable resource planning

Historically, national resource analyses have dealt with highly aggregated variables and an extremely low level of resolution. As a result, such analyses could not be validated or monitored. Attempts to disaggregate national planning results to local levels also have been generally unsuccessful.

A new report from the Rocky Mountain Station analyzes and evaluates one approach to utilizing local planning analyses of public renewable resource management agencies as an input in developing large-scale resource management plans. A type of multilevel approach is discussed and is evaluated in a test case.

The report, limited to efficiency-oriented analysis, is based on the assumption that the principal purpose of national planning in renewable resource agencies is to select the output mix to be produced and the means of producing it.

For your copy, write the Rocky Mountain Station and request *A Multilevel Optimization System for Large-Scale Renewable Resource Planning,* General Technical Report RM-130.

FIRECAST handbook available for estimating fire behavior

FIRECAST is a computer program that estimates up to six fire behavior parameters: rate of spread, fireline intensity, flame length, perimeter and area, scorch height, and ignition component. The program has been operationally tested for use in California.

The program offers three fuel model sets:

1) the Northern Forest Fires Laboratory (NFFL) fire behavior fuel models (Rothermel 1983);

2) the National Fire Danger Rating System (NFDRS) fuel models (Cohen and Deeming 1985); and

3) the Southern California (SCAL) brush fuel models (Rothermel and Philpot 1973).

The report describes the components of the FIRECAST program and contains the complete operating instructions, including guidelines for selecting a fuel model, and indicating environmental site data and fuel bed data. A sample run is also included.

This publication, *Estimating Fire Behavior With FIRECAST: User's Manual,* by Jack D. Cohen, General Technical Report PSW-90, is available from the Pacific Southwest Station.

Aspen in Utah classified

Utah contains over 1.6 million acres of aspen forests. These areas have traditionally been valued for livestock summer grazing, wildlife habitat, watershed production, and for scenic quality. Recently, aspen has been gaining importance for its potential to produce wood fiber.

A new report from the Intermountain Research Station provides a vegetation classification for aspen-dominated forests in Utah. To assist readers in identifying the 36 community types listed, the report contains a diagnostic key based on indicator plants.

Classifications and descriptions in the report are based on data gathered from 1,200 aspen stands scattered across six National Forests within Utah.

Request the publication, *Aspen Community Types of Utah*, Research Paper INT-362.

Public attitude on wilderness fire studied

Resource managers and specialists may understand the importance and usefulness of planned fire, but what does the public think? After years of Smokey-the-Bear campaigns, how will they react to closures of areas and trails, increased air pollution from smoke, and other inconveniences related to a management policy that lets some fires burn? Has the public's attitude toward fire changed as a result of information on the positive role fire plays in nature?

To find out, University of Montana Professor Stephen McCool and INT Research Social Scientist George Stankey quizzed visitors to the Selway-Bitterroot Wilderness on their understanding of fire and asked them about their thoughts regarding its use. These responses were then compared to results from a similar study conducted 14 years earlier.

In the resulting Intermountain Station report, the authors document an improved understanding by the public of the importance of fire, and a greater acceptance of fire as a management tool than in the past. The results of the study suggest that information given to the public may be helpful in increasing knowledge levels and changing attitudes.

To obtain your copy of the report, request *Visitor Attitudes Towards Wilderness Fire Management Policy, 1971-1984*, Research Paper INT-357.

Changing roles of the forest products industry

Economic Impacts of Interregional Competition in the Forest Products Industry During the 1970's, The South and the Pacific Northwest, an analysis of the changing roles of the forest products industries of the South and the Pacific Northwest, is now available from the Pacific Northwest Research Station. Two related publications, focusing on South Carolina and Kentucky (part of a series addressing the performance and contributions of the forest products industry to the economies of each of the 13 Southern States), are also available.

According to the interregional report, the Pacific Northwest dominated national markets for softwood lumber and plywood until the 1970's. As production increased in the South and Canada, the Northwest's share declined, resulting in a drop in the Pacific Northwest's share of the Nation's lumber and wood products employment during this period.

The author points out that without imports of softwood lumber from Canada, domestic lumber prices would have risen even higher than they did during the 1970's, and "as a consequence" would have prompted more use of wood substitutes. Thus, although Canadian lumber imports cost domestic jobs in the short run, they could mean higher employment in the Northwest forest products industry in the future.

Other authorities have predicted a shortfall of lumber production in Canada. The report suggests that this, in conjunction with the unexpected leveling off of softwood timber inventories in the South, could result in the return of the Pacific Northwest to its national dominance as a supplier of solid softwood products. Measures to reduce the cost of raw material, labor, and processing will further enhance the forest products industry's contribution to future, growth and development in the Northwest.

The publication also compares average annual wage and salary earnings in the forest products industry; comparative changes in annual wage and salary earnings; profits before taxes per worker hour; and each region's changing national share of forest products industry employment.

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To order any of the publications listed in this issue of *Forestry Research West*, use the order cards below. All cards require postage. Please remember to use your Zip Code on the return address.

Please send the following Pacific Northwest Station publications:

- ☐ *Management Practices and Options*, General Technical Report PNW-189.
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- ☐ *Regeneration Outlook on BLM Lands in the Siskiyou Mountains*, Research Paper PNW-349.
- ☐ *Economic Impacts of Interregional Competition in the Forest Products Industry During the 1970's, The South and the Pacific Northwest*, Research Paper PNW-350.
- ☐ *South Carolina's Forest Products Industry: Performance and Contribution to the State's Economy, 1970 to 1980*, Research Paper PNW-351.
- ☐ *Kentucky's Forest Products Industry: Performance and Contribution to the State's Economy*, Research Paper PNW-354.
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- ☐ *Feasibility of Collecting Firewood with a Small Skyline*, Research Note 468.
- ☐ *Snag Requirements of Cavity-nesting Birds: Are USDA Forest Service Guidelines Being Met?*, a reprint.
- ☐ *A Multilevel Optimization System for Large-scale Renewable Resource Planning*, General Technical Report RM-130.
- ☐ *Silvicultural Systems and Cutting Methods for Old Growth Spruce-fir Forests in the Central and Southern Rocky Mountains*, General Technical Report RM-126.
- ☐ *Silvicultural Systems and Cutting Methods for Old Growth Lodgepole Pine Forests in the Central Rocky Mountains*, General Technical Report RM-127.
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- ☐ *Below-Cost Timber Sales: Analysis of a Forest Policy Issue*, General Technical Report INT-183
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- ☐ *Fire Danger Computations with the Hewlett-Packard HP-71B*, General Technical Report INT-199.
- ☐ *Fire Behavior Computations with the Hewlett-Packard HP-71B Calculator*, General Technical Report INT-202.
- ☐ *Visitor Attitudes Towards Wilderness Fire Management Policy, 1971-1984*, Research Paper INT-357.
- ☐ *Aspen Community Types of Utah*, Research Paper INT-362.
- ☐ "The Horse Creek Study", a videotape.
- ☐ Other ____________________

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Please send the following Pacific Southwest Station publications:

- ☐ *Growth of California Red Fir Advance Regeneration After Overstory Removal and Thinning*, Research Paper PSW-180.
- ☐ *Estimating Fire Behavior with FIRECAST: User's Manual*, General Technical Report PSW-90.
- ☐ *Guide to Testing Insecticides on Coniferous Forest Defoliators*, General Technical Report PSW-85.
- ☐ *Developing Fire Management Mixes for Fire Program Planning*, General Technical Report PSW-88.
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The two companion reports focus individually on the forest products industry in South Carolina and Kentucky. They examine the growth of employment and earnings in the industry between 1970 and 1980, and the industry's share of each State's economic base. The national share of forest products employment and earnings in each State, as well as the productivity of different segments of the industry (such as pulp and allied products, lumber, or wood furniture) is also discussed.

The reports highlight the role of the forest products industry in each State's economic base, and its comparative importance in terms of growth, efficiency, employment, earnings, and timber dependency. They also look at the relative importance of different segments of the forest products industry to the South and the Nation, as well as within each State.

In both States—as in much of the South—the growth of the forest products industry resulted from the increasing size and amount of timber, investment in new plants and equipment, and increasing demand for their forest products. For more information, ask for *Economic Impacts of Interregional Competition in the Forest Products Industry During the 1970's, The South and the Pacific Northwest, PNW-350; South Carolina's Forest Products Industry; Performance and Contribution to the State's Economy, 1970 to 1970,* PNW-351; and *Kentucky's Forest Products Industry: Performance and Contribution to the State's Economy, PNW-354.*

Fire danger/fire behavior on the HP-71B

Fire management personnel can now use the handheld HP-71B calculator to compute both National Fire Danger Rating indexes and fire behavior estimates.

Two Intermountain Research Station publications by Research Forester Robert Burgan and Chemist Ronald Susott describe the calculator and its program features. In *Fire Danger Computations with the Hewlett-Packard HP-71B,* General Technical Report-INT-199, instructions are provided for calculating fire danger ratings in two ways—from standard National Fire Danger Rating System weather observations or by directly entering fuel moistures, wind speed, and slope.

The companion publication, *Fire Behavior Computations with the Hewlett-Packard HP-71B Calculator,* General Technical Report-INT-202, describes the inputs needed and the outputs calculated by a 13 module fire behavior program. This program is very similar to the Fire 1 program of the BEHAVE fire behavior prediction system. The manual provides sample worksheets and completed examples for each program module.

Copies of both publications are available from the Intermountain Research Station.

Videotape summarizes forest road/watershed study

The effects of forest road construction on water quality and the environmental effects and feasibility of alternative road construction and erosion control practices are described in the videotape, "The Horse Creek Study."

The 15-minute color presentation summarizes information resulting from a cooperative Intermountain Research Station/Northern Region study on the Nez Perce National Forest. INT Hydrologist Jack King, featured on the videotape, thinks the presentation will appeal to a wide audience. "The intended audience is field personnel on National Forests and other groups concerned with water quality and forest road construction," said King. "We avoided presenting specific data, instead presenting results of the study in general terms so that the videotape will be a practical tool in describing the results of our research."

The videotape is available for loan in 3/4 inch format from the Intermountain Research Station.